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Process and apparatus for conversion of heat energy into mechanical energy

Description

The invention refers to the process of the conversion of heat energy into mechanical energy by means of changing volume, pressure and temperature of the work medium, primarily gas in number of steps, and simultaneously refers to the apparatus for performing this process, too.

There are known concepts of the conversion of heat energy into mechanical energy, where temperature and pressure is changed in the workspace with alternately changing volume. During the volume decreasing, temperature and pressure increases both due to this volume change and primarily, in the last stage, due to the volume decreasing, or optionally, in the first stage of the volume reincreasing, by the additional supply of heat energy either from the exterior, or from the heat generation (e.g. combustion) inside the workspace. During the volume reincreasing, the pressure (originated from the previous workspace volume decreasing) performs, after loss deduction, work needed for consecutive volume decreasing. While the pressure, originated from the additional heat energy supply, performs, after the loss deduction, the resultant mechanical work. At the permanently closed work space concept, the work medium temperature (due to the additional heat energy supply) would be, at the end of the operating cycle, greater then the temperature at the beginning of the previous volume increasing. So that, during an exterior heat supply, the medium temperature would reach the temperature, where the heat

is supplied from the exterior and the temperature difference and also volume of the supplied heat would be, without view to the losses, zero. The heat supply, developed in the medium, would stop for the lack of oxygen, at permanently closed workspace. It is therefore necessary to open the workspace for the used medium exhaust and the fresh medium supply for a certain time, namely both at the beginning of the volume decreasing, or before it and at the end of the volume increasing, or after it. The power cycle of the pressure and temperature variations, during the volume increasing and decreasing, proceeds in two stages. If there are other two stages added to the previous ones (i.e. volume increasing for the used medium supply and volume decreasing for the used medium exhaust) then there is the four-cycle process of the conversion of heat energy into mechanical energy implemented. If the medium supply and exhaust take places at the beginning of the first stage, or respectively at the end of the second one, then there is the two-cycle process implemented. All of these processes take places according to the known state of art in one workspace, exceptionally divided into two parts.

Work medium is sucked according to the invented conversion of heat energy into mechanical energy by means of pressure and temperature change of the work medium into the first stage simultaneously with the volume increasing of this stage, whereon it transfers into the second stage during the first stage volume decreasing, whereon it transfers (during the second stage volume decreasing) through the third stage, simultaneously with the fourth stage heat supply and simultaneously with this fourth stage volume increasing, whereon it transfers from the fourth stage (during its stage volume decreasing) into the fifth stage, where it is let to be

expanded. The concept is according to the invention described by the transfer of work medium through the third stage simultaneously with the second stage decreasing, simultaneously with warming, into the fifth stage, or can be described by cooling during the transfer of the medium through the first stage into the second one. Other attribute of the invention is that the work medium is transferred, simultaneously with its cooling, from the fifth stage into the first stage simultaneously with this first stage volume increasing. The concept can be, according to the invention, modified so that the work medium is transferred from the fifth stage, simultaneously with its volumen decreasing, into the third stage and is used for the warming process, or that the fifth stage is joined with the first stage and simultaneously with decreasing of the volumen of this joined stage is work medium (optionally with the simultaneous cooling) transferred directly into the second stage, simultaneously with increasing des volumens of this second stage. The apparatus for a multistage conversion of heat energy into mechanical energy by means of changing volume, pressure and temperature of the work medium has the third stage in form of a workspace with an invariable volume, while the other stages are arranged as workspaces with variable volume (particularly as piston machines with the revolving piston) and are functionally, in a way of the work medium transfer, arranged one behind the other, partly before the third stage and partly behind the third stage. The apparatus for performing the invention concept is furthermore adapted in a way, so that the largest volume of the first stage is larger then the largest volume of the second stage, while the largest volume of the fifth stage is larger than the largest volume of the fourth stage, while the largets volume of the fifth stage is larger than the

largest volume of the first stage or equal to the largest volume of the first stage. The apparatus, according to the invention, can be furthermore arranged, so that the fifth stage concurrently forms the first one. According to the next invention character, the third stage is created as a combustion chamber and/or a heat exchanger. The invention is furthermore expediently adapted so that the fifth stage is equipped by the inlet valve. According to the last invention character, the cooler is inserted between the first stage and the second stage, and also between the fifth stage and the first stage and also between the joined stage and the second stage.

The invention can be closely seen on the attached drawing. The basic invention concept can be seen on Picture 1. Picture 2 shows a version with the cooler between the first stage and the second stage and also between the fifth stage and the first stage and Picture 3 shows a concept with the first stage joined together with the fifth stage and a concept with the cooler between the fifth stage and the second stage.

Work medium is brought into the first stage 1 during the first stage volume increasing, see Picture 1, whereon it is, during the first stage 1 volume decreasing, transferred into the stage 2, simultaneously with its volume increasing. It is then, during the second stage 2 volume decreasing, transferred into the third stage 3. While transferring through the third stage 3, heat is supplied into work medium either from inside by fuel combustion, or from outside by the third stage heating e.g. by exterior combustion. Work medium is transferred from the third stage 3 into the fourth stage 4, whose volume

simultaneously increases, whereon it is, from the fourth stage 4, concurrently with its volume decreasing, transferred into the fifth stage 5. In this fifth stage 5, the work medium is allowed to expand within its volume increasing. Work medium is after its expansion, concurrently with the fifth stage 5 volume decreasing, either conducted outside, or inside back into the first stage 1. When using air as a work medium and exterior combustion as a concept of the heat supply into the third stage, it is convenient to use expanded, but hot, air for the inside combustion. The invented concept therefore presents five-cycle thermo dynamical cycle. There can be convenient; in some cases, to avoid the fourth stage 4 and to transfer work medium into the fifth stage and allow it to expand in this stage. It is convenient, when work medium is cooled inside the interstage cooler 6, during its transfer from the stage 1 into the second stage 2 (see Picture 2). In the closed cycle, where the work medium is transferred from the fifth stage 5 back into the first stage 1, it is convenient to insert other interstage cooler 7 between the fifth and the first stage. It is also convenient, in some cases, according to the other invention concept, to join the fifth and the first stage into the joined stage 51 and to transfer (during this joined stage volume re-decreasing) work medium, expanded during the joined stage 51 volume increasing, into the second stage 2, simultaneously with this second stage increasing, optionally through the joined interstage cooler 76. The basic five-stroke cycle is, in this case, adapted into the three-stoke cycles.

The apparatus, as described above, performing the conversion of heat energy into mechanical energy is according to the invention, arranged in a way, so that the third stage 3

composes from, at least, one workspace with an invariable volume, while the other stages 1, 2, 4, 5, 51 are created as workspaces with the variable volumes. It is convenient to create all the stages, excluding the third one, as piston machines with the revolving piston. In such concept where, the cusps edges join together during the piston revolution above each plane, the space volume enclosed by this area and the inclined inside cylinder plane, where the piston revolves in, decreases. Hereat, the largest volume of the first stage 1 is larger than the largest volume of the second stage 2, and furthermore, the largest volume of the fifth stage 5 is larger than the largest volume of the fourth stage 4 and the largest volume of the stage 5 is larger than the largest volume of the stage 1. The largest volume of the joined stage 51 is larger than the largest volume of the stage 4 and also larger than the largest volume of the stage 2. The third stage 3 is created as a combustion chamber and/or as a heat exchanger. Work medium is firstly supplied (e.g. by sucking) into the increasing volume of the first stage 1. After reaching maximum, the volume of this stage begins to decrease and work medium is exhausted into the increasing volume of the second stage 2. Because the largest volume of the second stage is many times smaller than the largest volume of the first stage 1, the state of work medium changes so that, after its shift from the first stage 1 into the second stage 2, this medium has higher pressure and also higher temperature. If the temperature increase is not desirable, it is possible to insert the interstage cooler 6 between both of the stages according to the Picture 2. During the volume re-decreasing of the second stage 2, work medium is transferred from it through the third stage 3 into the fourth stage 4, while increasing its volume. Heat is supplied into work medium in the third

stage 3 either by inside combustion, where the stage is made as a heat exchanger, or by inside combustion in a way of the combustion in the turbine's combustion chambers, but under considerably higher pressure. Because the largest volume of the fourth stage 4 is generally equal to the largest volume of the second stage 2, work medium has in the fourth stage 4, after warming in the third stage, in the final state, higher pressure and also higher temperature contrary to the initial state in the second stage 2. Work medium expands from decreasing volume of the fourth stage 4 into increasing volume of the fifth stage 5, where it performs work. It is also possible to adapt this apparatus according to the invention, so that the largest volume of the fourth stage 4 is larger than the largest volume of the second stage 2, so that the partial isobaric to isothermal expansion between both of the stages will occur and this adaptation will reach Carnot's cycle concept. In an extreme case, it is possible to completely avoid the fourth stage and to let work medium expand from the second stage 2, during warming in the third stage 3, into the fifth stage 5. The third stage has a nonzero volume so that, if there is no heat supplied, the partial expansion occurs at the beginning of the work medium transfer and after transferring through the third stage into the fourth stage, work medium has lower pressure and also lower temperature then in the second stage. However, due to this lower pressure, the fourth stage takes proportionally lower weighted quantity of work medium than it is supplied into the third stage from the second stage and the residual quantity generates, or optionally increases, the residual pressure in the third stage. According to the size of the third stage, in this manner also without heat supply, the pressure in the third stage very quickly rises, so that expansion, within the

work medium transfer from the second stage into the third stage, does not occur and it is possible to supply heat under the pressure given by compressed work medium from the first stage into the second stage. It is therefore possible to dimension the third stage both as a combustion chamber with a small external area, so that needles heat leak does not occur, and as a heat exchanger with a large area, so that it is possible to supply the largest heat quantity possible. In order to supply the largest possible heat quantity into the third stage and to decrease the work expended during the compressional stage of the cycle, it is, if possible, needed to decrease temperature during the transfer from the first stage into the second one. It is, according to the invention, enabled by inserting the interstage cooler 6 between the first stage 1 and the second stage 2. At the enclosed cycle, where work medium is transferred from the fifth stage 5 back into the first stage 1, it is appropriate to insert an innerstage cooler 7 between these two stages. At the configuration according to the invention, it is possible to choose, independently upon the compression ratio, magnitude of the expansion ratio, so that it is possible to expand compressed to the pressure of the surrounding environment and heated work medium, whereby a good cycle efficiency is reached. At the given expansion ratio, the pressure at the end of the expansion is given by magnitude of the pressure at its beginning and this pressure, at the end of the expansion, can therefore, at the smaller heat supply, drop under the surrounding environment pressure. If this phenomenon is not desirable, it is possible to use other invention character i.e. additional work medium inlet through the inlet valve 8 at the end of the expansion. The power cycle, realized according to the invention concept and apparatus, is therefore five-

stroke cycles. At certain expansion ratio magnitude in the fifth stage 5 (i.e. the ratio between the largest volumes of the fifth and fourth stages), not only the pressure at the end of the expansion, but also the temperature drops to the value of the surrounding environment. It is therefore possible at the enclosed cycle and at the outside work medium warming, which take place in the third stage 3, according to the other invention character, to join the fifth stage 5 with the first stage 1 according to the Picture 3 and to transfer work medium after expansion in the convenient way from the joined stage 51 through the interstage cooler 76 into the second stage 2 concurrently with its compression. In this case, it is also desirable to equip the joined stage 51 by the inlet valve 8. It is therefore possible, in some cases, within the invention, to adapt the five-stroke cycle to the three-stroke cycle.

The invention is, both according to the design examples and also according to the other designs resulting from the patent requirements and comparing to the other known heat engines, more convenient especially by its possibility to allow higher working pressure and temperature then turbine engines, longer warming of the compressed work medium and lower pressure and temperature at the end of the expansion then so far know piston engines. Higher cycle efficiency, lower emissions of the carbon and nitrogen oxides, lower noise in the case of work medium warming by external or internal combustion is the outcome of the invention. It is also possible to use this invention for the conversion of solar energy into mechanical energy.